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Research Note

Gene effects, heterosis and inbreeding depression in Pigeonpea, *Cajanus cajan* L.

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Abstract:
The P1, P2, F1, F2, B1 and B2 of four pigeonpea, *Cajanus cajan* L. crosses were studied for eight metric traits. Individual scaling tests and joint scaling test indicated that an additive-dominance model was adequate in *viz.*, PRG 100 x ICPL 87119, LRG 300 x ICP 8863 for number of primary branches per plant and LRG 300 x ICP 87119 for number of primary branches per plant and number of pods per plant. The results of the rest of the cases suggested the presence of additive, dominance and epistatic gene effects especially for the traits viz., seed yield and test weight.. Duplicate type of epistasis was prevalent in most of the cases. A substantial amount of heterobeltiosis over better parent (HBP) was revealed in all the four crosses for seed yield per plant and for most of its attributes. Inbreeding depression was also observed significant for days to 50% flowering, days to maturity and number of clusters per plant in the cross PRG 100 x ICPL 87119 indicating the presence of dominance gene action. Suitable breeding strategies were suggested for the improvement of seed yield in pigeonpea.

Key words: Gene effects, pigeonpea

Pigeonpea, *Cajanus cajan* L. is an important pulse crop of arid and semi-arid regions. Studies on nature of gene action governing complex quantitative traits are of great value to the plant breeders in selecting appropriate breeding methodology for the improvement of yield contributing traits. Such studies have been also reported by Oomen *et al.,* (1994) in pigeonpea. Information on the presence of type of epistatic gene effects in the inheritance of various quantitative traits is important for adopting suitable breeding procedures to improve the traits. In the present study, an attempt has been made to know the nature and magnitude of additive, dominance and epistatic gene effects for quantitative traits in four crosses of pigeonpea.

Six basic generations *viz.,* P1, P2, F1, F2,B1 and B2 derived from four crosses viz., PRG 100 x ICP 8863, PRG 100 x ICPL 87119, LRG 30 x ICP 8863 and LRG 30 x ICPL 87119 were produced and evaluated in a Randomized Block Design with three replications during *kharif* 2008-09 at Agricultural Research Station, Tandur, ANGRAU. ICP 8863 and ICPL 87119 are good combiners and wilt resistant lines. Each plot consisted of a single row of parents and F1s each, two rows of B1 and B2 each and three rows of F2 generation (20 plants in parents and F1 generation, 50 plants in B1 and B2 generation and 200 plants in F2 generation). Recommended package of practices were followed throughout the crop season. The observations were recorded on individual plant basis in each replication on randomly selected five plants in each parent and F1, 10plants in each of B1 and B2 and 20 plants in F2 generation for eight characters viz., days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of clusters per plant, number of pods per plant, test weight and seed yield in each cross (Table 1). The scaling test (Mather, 1949; Hayman, 1958) and joint scaling test (Cavalli, 1952) were applied simultaneously for the detection of epistasis. Heterosis over better parent (Foencsa and Patterson, 1968) and inbreeding depression were also worked out using Windowstat programme.

The analysis of variance revealed significant differences among six basic generation means in all the four crosses for all the eight characters. The estimates of genetic parameters, heterosis over better parent and inbreeding depression for different characters recorded in four crosses are presented in Table 1. Out of thirty two cases (four crosses and eight characters) adequacy of additive dominance model assuming no epistasis was established in twelve cases when both individual scaling test (A, B and C) and joint scaling test were applied simultaneously; in the remaining cases epistasis was evident. The joint scaling test was found to be more

efficient in detection of epistasis compared to individual scaling test as this test permits any combination of the six population at a time and it also provides the estimates of three genetic parameters viz., m,d, and h.; Golakia et al., (2004) in castor had also concluded superiority of joint scaling test over the simple scaling test. The twelve cases showing adequacy of scale were PRG 100 x ICPL 87119, LRG 300 x ICP 8863 for number of primary branches per plant and LRG 300 x ICP 87119 for number of primary branches per plant and number of pods per plant. Both additive (d) and dominance (h) gene effects in these non- interacting crosses were important in the inheritance of number of primary branches per plant and number of pods per plant .The dominance gene effect (h) contributed towards inheritance of number of pods per plant in these non-interacting crosses. These dominance gene effects could be exploited by heterosis breeding.

Among interacting crosses both additive and dominance gene effects contributed significantly towards days to 50% flowering, days to maturity, plant height, number of pods per plant, seed yield in the cross LRG 30 x ICP 8863 test weight in the cross PRG 100 x ICP 8863. Only dominance (h) was significant for all the characters except number of primary branches per plant and number of pods per plant in the cross PRG 100 x ICP 8863 whereas for the cross PRG 100 x ICPL 87119 showed dominance effects for days to 50% flowering, days to maturity, plant height, number of clusters per plant and number of pods per plant. The cross LRG 30 x ICPL 87119 exhibited dominance effects for all the characters except number of pods per plant and test weight. Neither additive nor dominance was significant for number of primary branches per plant for all the crosses except LRG 30 x ICPL 87119, number of pods per plant or the crosses PRG 100 x ICP 8863 and LRG 30 x ICPL 87119. The importance of additive or dominance gene effects in the inheritance of seed yield and its components was earlier reported by Gupta *et al*., (1997), Importance of only additive gene effects for seed yield were reported by Chandrasekhar *et al* ., (1998) while non additive gene effects for seed yield were reported by Hooda *et al.*, (2000).

In addition to main effects, digenic additive x additive interaction effect was significant for PRG 100 x ICP 8863, LRG 30 x ICP 8863 for days to 50% flowering, days to maturity and plant height whereas the cross PRG 100 x ICPL 87119 exhibited additive x additive gene effect for plant height and number of clusters per plant. The cross LRG 30 x ICP 8863 showed this type of gene effects for test weight and seed yield - per plant.The fixable gene effect (d) and (i) in these crosses could be helpful in isolation for superior lines of pigeonpea.The significance of i and j for the traits plant height and seed yield per plant in LRG30 x ICP 8863 manifested that the additive x dominance (j) gene effects were involved in the inheritance of plant height and seed yield per plant in the cross LRG 30 x ICP 8863Where as dominance x dominance gene effects were involved for number of primary branches per plant, number of pods per plant, in the cross PRG 100 x ICP 8863 and number of pods per plant and test weight in the cross PRG 100 x ICPL 87119 and test weight and seed yield in the cross LRG 30 x ICPL 87119.

A perusal of gene action in this study revealed both additive and non-additive gene effects were governing seed yield and its related traits (Table 1). Further duplicate type of epistasis was observed for most of the traits except days to 50% flowering, days to maturity and test weight in the cross PRG 100 x ICPL 87119, days to maturity, plant height, seed yield in the cross LRG 30 x ICPL87119. The presence of duplicate epistasis for most of the cases would be restricting rapid progress, making it difficult to fix genotypes with increased level of character manifestation . Complementary epistasis was observed for number of primary branches per plant, test weight and seed yield per plant in PRG 100 x ICP.Hence these traits could be exploited through hybrid construction. It is suggested that for the characters showing influence of digenic interaction in addition to main effects (d) and (h), population improvement approach in the form of biparental mating coupled with recurrent selection may be adopted. Such programme shall allow mild breeding in the population and enhance the possibilities of trangressive segregation and the span of selection over generations.

A substantial amount of heterosis over better parent was observed in all the crosses for seed yield per plant and most of its attributes. High and significant heterosis was observed for seed yield per plant , days to 50% flowering, number of pods per plant and days to maturity in all the four crosses and significant heterosis for number of primary branches per plant and number of pods per plant respectively. The heterosis in above cases would be due to presence of dominance (h) and dominance x dominance (l) gene effects. Joint action of favourable gene combinations at different loci could be responsible for observed heterosis in these crosses for most of the traits. Similar results were reported by Shrivastava *et al*., (1976)

Inbreeding depression was also observed significant for days to 50% flowering, days to maturity and number of clusters per plant in the cross PRG 100 x ICPL 87119. Inbreeding depression in F2 population for seed yield per plant ranged from 9.84 (LRG 30 x ICPL 87119) to 36.53 (LRG 30 x ICP 8863) per cent which might be due to wide base of genetic material in all the crosses. The positive inbreeding depression indicated the presence of dominance effects for most of the traits. Association of high heterosis with high inbreeding depression for seed yield per plant and some of its component traits were observed by Kumar *et al.,* (2002) and Valarmathi and Govil (1999) suggesting the presence of non additive gene effects.

In the present study involvement of both additive as well as non additive gene effects were observed in most of the cases. Therefore, heterosis breeding and population improvement adopting *inter se* mating among promising divergent genotypes and effecting simultaneous selection like recurrent selection or Biparental mating for number of primary branches per plant, number of pods per plant and seed yield is recognized as the ideal breeding approach for pigeonpea improvement programme.

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Table 1: Estimates of gene effects, heterobeltiosis (HB) and Inbreeding depression (ID) for eight characters in four crosses of pigeonpea

Crosses	M	d	h	i	j	l	HB	ID
Days to 50% flowering								
PRG 100 x ICP 8863	97.95** ±0.84	-7.57** ±0.72	20.70** ±3.68	10.73** ±3.66	-1.07 ±0.77	-2.80 ±4.49	11.54**	11.87
PRG 100 x ICPL 87119	107.07**±1.58	-10.03** ± 2.07	25.67** ±7.57	10.46 ±7.55	2.10 ±2.08	6.27 ±10.46	28.32**	13.38*
LRG 30 x ICP 8863	109.95**±1.21	3.00* ±1.19	24.40** ±5.43	7.26** ± 5.41	-1.40 ±1.23	-13.93* ± 6.87	12.58**	7.75
LRG 30 x ICPL 87119	119.30**± 0.80	-3.43** ±0.87	11.57** ±3.70	4.20 ±3.64	-2.20* ±0.91	-2.20 ±4.90	6.15**	4.52
Days to maturity								
PRG 100 x ICP 8863	158.20** ± 0.92	-7.57** ±0.61	18.43** ±3.88	12.33** ±3.86	-1.07 ± 0.68	-0.33 ± 4.48	6.87**	7.08
PRG 100 x ICPL 87119	165.63** ±1.64	-9.23** ±2.19	28.60** ±7.92	14.60 ±7.91	3.50 ± 2.23	6.13 ±11.03	10.09**	10.22*
LRG 30 x ICP 8863	169.95** ±1.22	3.00* ±1.19	22.93** ±5.43	17.27** ±5.41	-2.26 ±1.23	-11.00 ± 6.87	9.11**	5.11
LRG 30 x ICPL 87119	178.95** ±0.83	-1.03 ±0.89	13.16** ±3.83	5.33 ±3.78	-0.07 ± 0.99	6.13 ±5.03	5.56**	4.08
Plant height (cm)								
PRG 100 x ICP 8863	168.63** ± 1.32	-8.29** ± 1.61	31.31** ±6.27	15.07* ±6.19	-3.5*±1.71	-1.06 ±8.59	14.09*	5.81
PRG 100 x ICPL 87119	179.30 ** ± 2.03	-20.33**± 2.20	40.64** ±9.33	18.75* ±9.25	-4.71* ± 2.29	3.46 ±12.18	20.68**	4.98
LRG 30 x ICP 8863	179.12 ** ±1.88	18.87 ** ±1.69	43.69** ±8.33	22.73**±8.27	12.35** ±1.79	-3.61 ±10.33	7.85	2.40
LRG 30 x ICPL 87119	191.68** ±1.13	-6.59 ** ±1.53	13.56* ±5.56	3.41 ±5.46	-2.29 ±1.65	6.41 ±7.88	8.12	4.92
Number of primary branches per plant								
PRG 100 x ICP 8863	14.75** ±0.39	-0.67 ± 0.39	1.03 ±1.78	1.80 ±1.76	-0.17 ±0.49	6.40** ±2.29	24.40**	3.33
PRG 100 x ICPL 87119	14.93** ± 0.46	0.76 ±0.53	2.90 ±2.16	-	-	-	18.03**	-3.03
LRG 30 x ICP 8863	16.55** ± 0.56	0.77 ± 0.63	0.57 ± 2.66	-	-	-	24.16**	10.00
LRG 30 x ICPL 87119	15.52** ±0.59	-1.57** ±0.51	6.10* ±2.63	-	-	-	13.30*	0.00
Number of clusters per plant								
PRG 100 x ICP 8863	87.47** ± 1.26	-2.97** ±1.12	23.50** ±5.56	11.27* ± 5.51	1.07 ± 1.23	-10.37 ±6.89	4.87	8.33
PRG 100 x ICPL 87119	83.00** ±1.62	-5.56** ± 1.92	35.27** ±7.60	23.40** ±7.55	0.30 ±1.98	-10.53 ±10.23	2.82	14.04*
LRG 30 x ICP 8863	82.37** ±1.39	-12.20** ±1.67	17.70** ±6.59	8.00 ±6.47	-6.43** ±1.77	4.20 ±9.04	6.47	13.40
LRG 30 x ICPL 87119	84.73** ±1.43	-7.70** ± 1.35	33.33** ± 6.48	20.73** ± 6.40	-0.10 ±1.46	-17.60* ±8.18	-0.49	9.04
Number of pods per plant								
PRG 100 x ICP 8863	419.52** ±5.45	-4.60 ±6.02	12.00 ±25.14	-68.60** ± 24.89	-0.47 ±6.25	167.00** ± 33.25	50.13**	22.61
PRG 100 x ICPL 87119	417.32** ±5.76	-31.63** ±6.61	56.47* ±26.88	-26.93 ±26.59	11.90 ±7.03	160.47** ±36.00	28.18**	-0.95
LRG 30 x ICP 8863	417.57** ±6.65	30.03** ±9.58	147.00** ±32.89	72.609* ±32.77	-17.30 ±9.73	-52.53 ± 46.98	49.67*	22.55
LRG 30 x ICPL 87119	433.62** ±6.86	-3.30 ±8.09	43.20 ±32.39	-	-	-	24.94**	30.45
Test weight (g)								
PRG 100 x ICP 8863	12.98** ±0.21	0.31 ±0.34	2.38* ± 1.10	1.23 ±1.08	-0.13 ±0.35	0.01 ± 1.65	0.92	10.80
PRG 100 x ICPL 87119	12.27** ±0.22	0.84** ±0.29	4.76** ±1.08	1.27 ±1.07	0.28 ±0.31	6.93** ±1.49	-5.02	8.54
LRG 30 x ICP 8863	10.33** ±0.27	-2.20** ±0.27	5.66** ±1.23	3.51** ±1.22	-0.36 ±0.29	-1.06 ±1.57	-0.31	8.37
LRG 30 x ICPL 87119	11.21** ±0.24	-1.88** ±0.29	0.91 ±1.15	-1.01 ±1.22	-0.17 ±0.32	3.48* ±1.59	-4.85	-2.08
Seed yield (g/plant)								
PRG 100 x ICP 8863	53.68** ±0.82	0.69 ±1.06	13.91** ±3.93	5.11 ±3.89	1.36 ±1.11	6.72 ±5.44	48.78**	25.30
PRG 100 x ICPL 87119	55.24** ±0.66	-4.15**±1.04	1.19 ±2.42	-9.04** ±3.38	-3.51**±1.09	31.49** ±5.02	25.92**	29.71
LRG 30 x ICP 8863	53.35** ±0.54	3.16** ± 1.08	23.52** ±3.16	14.73** ±3.05	3.88**±1.13	-11.46** ± 5.09	53.14**	36.53*
LRG 30 x ICPL 87119	54.56** ±0.57	-1.98** ±0.79	15.39** ± 2.87	4.37 ±2.79	-1.28 ±0.86	8.76* ±4.15	33.88**	9.84